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TUBERCULOSIS OF HOGS:
ITS CAUSE AND SUPPRESSION.

BY

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INTRODUCTION.

Tuberculosis in the human family has been lessening materially during the past fifteen years, but reports from the various meat-packing centers of the country fail to show the same encouraging condition regarding tuberculosis in hogs during the same space of time. It must be admitted that reports have come from several localities during the past four years showing a decrease in the number of tuberculous swine sent to market, but a review of the collective records of the country at large shows an increase rather than a decrease in the number of swine affected. Indeed, there is probably no disease of hogs, not even excepting hog cholera, which is causing heavier losses to the hog raiser than tuberculosis, and it is also the cause of great loss to the packers and of much anxiety to the veterinary inspector of meats. Until recent years tuberculosis had been looked upon as of uncommon occurrence, and only of importance from a meat-inspection standpoint; but to-day it must be considered as a general veterinary problem, theoretically easy of solution, which should receive the careful attention of all sanitarians.

The swine of this country January 1, 1908, according to estimates of the Bureau of Statistics of the Department of Agriculture, numbered 56,084,000, and their value at that time was \$339,030,000. From these figures one may partially realize the serious menace to the hog-raising industry which is offered by a disease which affects almost 1.5 per cent of all hogs slaughtered at the abattoirs of this country which have Federal inspection. Reports from European abattoirs show that tuberculosis is far more widespread among their hogs than among ours, some of the returns showing as high as 5.5 to 7.5 per cent. It is to be hoped that the spread of the disease in this country may be checked, and that concerted action by the stock owners and veterinarians may lead to the complete eradication of this costly affection.

The small amount of money required to begin hog raising and the quick returns on the capital invested make this industry an attractive one to the small farmer. The hog will make a pound of gain on less feed than most live stock, and will profitably utilize waste food products of every variety if properly prepared for him. As tuberculosis in this species is chiefly acquired by ingestion, the significance of the latter statement is obvious.

Tuberculosis of hogs is closely associated with the same malady in cattle. The reason for this is apparent when one considers the close relations of these two species of domestic animals upon nearly every farm. The Bureau of Animal Industry is at present endeavoring to locate infected farms, or at least infected localities, and to ascertain the direct cause of the spread of the disease in these districts. Owing to the number of hands through which hogs go before reaching the abattoirs this is not an easy proposition, but it can be and is being accomplished. Already through cooperation with the State authorities a large number of infected farms have been definitely located. The conditions on these farms have been investigated, the source of the disease determined, and methods for its suppression recommended. In Wisconsin the Bureau and State officials have been working with these ends in view. When hogs have been found to be tuberculous and the farm from which they came has been located, the State veterinarian is notified, and he is empowered by law to quarantine any farm when he suspects the presence of a contagious disease thereon. He then applies the tuberculin test to the cattle on the farm and otherwise looks for the source of infection. This frequently results in finding the cattle tuberculous. Similar cooperation has recently been taken up with Nebraska, Iowa, and Minnesota, and the results are equally encouraging.

This cooperation with the State is of great value, and the results would be of greater magnitude if State legislation could be secured compelling the tagging of all hogs going to slaughter, whereby these animals if found tuberculous could be, immediately traced to their point of origin and the source of infection removed. It is evident that the suppression of hog tuberculosis would save the country millions of dollars annually, and when it is realized that there are vast numbers of tuberculous hogs killed in abattoirs having no inspection of any kind, it can be seen that the danger to human life from this source would at the same time be removed.

PREVALENCE OF THE DISEASE.

The prevalence of tuberculosis among swine must be judged from abattoir statistics entirely. Thus it has been noted from the records kept by the Bureau of Animal Industry that some sections of the country contribute a far greater proportion of diseased animals than

others. Hogs from Arkansas, Oklahoma, and Texas are remarkably free from this disease, due probably to the method of caring for them, or rather the lack of caring for them. They are not hampered in feed lots as those are in the sections where the disease is mostly found, but are allowed to roam over large areas of pasture and to shift for themselves, and when they are found affected the majority of them show very slight lesions. Furthermore, no prolonged feeding is practiced in narrow bounds as in the corn belt. Lastly, there are relatively few dairies in these sections, and likewise few tuberculous cattle. On the other hand, the hogs are carried from birth to maturity on some form of pasture, as alfalfa, oats, corn, cowpeas, sorghum, rape, and peanuts all the year round. The hogs of the forest region of Hungary which are pasture fed are likewise rarely tuberculous, according to Hertwig, and there can be no doubt that swine fed on entirely vegetable food, as corn and roughage, are proportionately less affected than those fed on dairy products or behind diseased cattle.

A great many hogs in Texas are raised on alfalfa supplemented with corn, and the result is clearly shown in the Bureau statistics which indicate that from January 1 to June 30, 1907, only one-tenth of 1 per cent of over 325,000 hogs slaughtered at Fort Worth showed tuberculous lesions, while only 51, or 0.016 per cent, were condemned as unfit for food. In striking contrast to this may be given the percentages for the same period of three cities in one of the leading dairy States, which show 3.1 per cent, 3.4 per cent, and 6.4 per cent, respectively, of the hogs slaughtered to be affected with tuberculosis. There are a large number of cooperative creameries in the territory contiguous to the three cities alluded to, and the raw skimmed milk is taken home by the patrons for their hogs. Samples of separator slime from the two creameries in the town showing the largest number of tuberculous hogs were injected into guinea pigs and in one instance virulent tubercle bacilli were recovered.

The hog buyers for packing houses are from bitter experience gradually becoming familiar with these conditions and are avoiding certain sections of certain States, and there are at least two eastern packers who will not under any conditions kill hogs from one of the badly infected States. In other localities the packers are beginning to take self-protective measures so as to have the feeder of diseased hogs bear the burden, and many of the smaller establishments in the Central West are buying hogs subject to post-mortem inspection. This attack on the farmer's purse will probably have more beneficial results in making him fully alive to the seriousness of the situation than any other procedure.

In an endeavor to trace the origin of the infection of tuberculous hogs that were arriving at one of the packing plants of Iowa, Rogers of

the Bureau of Animal Industry for some time carried on an experiment which consisted in tagging the hogs that were hauled to market at that place in wagons, before they were removed from the farmers' wagons, and later using these tags as means of identification in case tuberculosis was found to exist in any of the hogs at the time of slaughter. In this manner 3,420 hogs were tagged, and on tracing them to their final disposal it was learned that all of the tuberculous live stock brought to that market came from a few farms—less than 6 per cent of the total, while the remaining 94 per cent of the farms were free from the disease. This proportion of noninfected farms should give great encouragement to any efforts that may be made to eradicate the disease from the State. It was further noted that the successive shipments of hogs marketed by certain farmers always contained tuberculous animals, and in at least two instances the entire consignments were condemned for tuberculosis at the time of slaughter.

PREVALENCE OF TUBERCULOSIS IN FOREIGN COUNTRIES.

Statistics of the sanitary inspection of the Federal slaughter-houses in the Argentine Republic show that the percentage of tuberculous swine is greater than that of tuberculous cattle. This fact is also true in this country, although the contrary is shown in the greater part of the European countries.

In the abattoirs of Buenos Aires the percentage of tuberculous swine for several years past was as follows:

Year.	Percent.	Year.	Percent.
1898.....	6.50	1903.....	10.86
1899.....	6.50	1904.....	10.23
1900.....	8.90	1905 to November.....	8.98

In the abattoirs of Liniers at the above city the relation of the two forms of tuberculosis in swine is represented by the following figures:

Proportion of generalized and localized tuberculosis of hogs found at abattoirs of Liniers, Buenos Aires.

Year.	Hogs slaughtered.	Affected with generalized tuberculosis.		Affected with localized tuberculosis.	
	Number.	Number.	Per cent.	Number.	Per cent.
1898.....	36,128	1,160	3.21	1,200	3.32
1899.....	33,066	1,161	3.51	1,273	3.85
1900.....	37,824	967	2.58	2,420	6.40
1903.....	43,581	475	1.09	4,255	9.77
1904.....	41,577	375	.90	3,881	9.33
1905.....	48,077	630	1.31	3,689	7.67

It is seen that there is a striking difference in the relative percentages of the two forms of tuberculosis in the later years as compared with the earlier ones. In the first two years the proportion of generalized tuberculosis is practically the same as the localized, whereas in the later years the generalized has decreased considerably, while the localized has increased to an even greater degree.

From the report of the operations of the veterinary sanitary service of Paris it seems that the appearance of tuberculosis among the hogs that are sent to the abattoirs of that city for slaughter is comparatively rare. Although the statistics which are preserved may not give exact data as to the frequency of tuberculosis among the hogs of that region, they are still accurate enough to show that the disease does not cause any serious losses to the swine breeders of France. The French explain this slight infection by stating that the heaviest losses always occur in countries in which dairy interests have become largely developed.

Deetz finds that tuberculosis exists among the hogs of Germany in differing degrees in the several regions. It is more prevalent in the northern than in the southern part of the country. He has prepared tables showing the number of tuberculous swine condemned at the various abattoirs and for purposes of comparison has included the numbers of tuberculous cattle which have been found at the same abattoirs. These tables show that tuberculosis, both of swine and cattle, is increasing. For instance, during 1883-4 only 0.53 per cent of the swine slaughtered at Berlin were found to be tuberculous, while the records for 1897-8 show 3.9 per cent tuberculous, and later reached as high as 5.79 per cent in one year, although only animals which appear to be perfectly sound are allowed to enter the Berlin slaughterhouses.

For the entire Kingdom of Saxony a percentage of 4.81 has been reached, while in the Kingdom of Bavaria records kept for nine years show that only in the year 1903 were tuberculous hogs found in excess of 1 per cent.

The records from different cities in Great Britain show considerable variation in the percentage of tuberculous animals found among the pigs slaughtered. Thus the Birkenhead town slaughterhouse reports 207 tuberculous pigs out of 22,852 slaughtered (nearly 1 per cent). The veterinary inspector at the London corporation slaughterhouses at Islington found 75 affected pigs out of 15,225 examined (or about $\frac{1}{2}$ per cent), while returns from the inspector of the Glasgow corporation show that 2,553 affected pigs were found among 60,235 slaughtered (4.24 per cent).

Reports from the Netherlands state that during the examination of 368,428 native pigs that were intended for export to London 5,516 tuberculous animals were found, or 1.5 per cent.

In New Zealand during the fiscal year 1907, out of 100,731 hogs examined 5.89 per cent were found affected with tuberculosis, and 4.55 per cent were partially condemned and 0.87 per cent totally condemned.

Taking into account the foregoing figures for the foreign countries mentioned, one may appreciate more accurately the great tribute which each year is paid to this scourge of man and beast by the hog industry. All statistics show after a general style that the greatest increase in tuberculosis among hogs occurs in those sections where the dairy industry is the most advanced, like Copenhagen and Douzig, in Denmark, which show 15 and 70 per cent, respectively (1897), giving as the principal cause of this the use of the by-products of the dairy in the feeding of swine.

PATHS OF ENTRANCE OF TUBERCLE BACILLI.

As a result of numerous experiments conducted on hogs it has been quite conclusively shown that hog tuberculosis is an ingested disease and that the tubercle bacilli are absorbed almost at the beginning of the alimentary canal. The tonsils of pigs have been examined by several investigators, including ourselves, and tubercle bacilli have been found in the apparently normal tonsillar crypts. From the tonsils to the submaxillary glands is but a very short distance and on a direct line with the lymph current in the lymphatic vessels. This fact, taken into consideration with the infection of the submaxillary glands in over 93 per cent of all tuberculous hogs, shows that the tonsils play a very important part as the portals of entry of the tubercle bacillus. Again, the scavenging propensities of hogs, whereby they eat various substances, rough or smooth, hard or soft, sharp or blunt, including wood, nails, wire, etc., make it quite possible for such things to be taken into the mouth with food in such a way as to cause sufficient abrasion of the mucous membrane to permit the entrance of the bacillus, and its absorption by the lymph vessels and subsequent deposit in the submaxillary gland follow. Young pigs at the time of teething are particularly liable to become infected owing to the abrasions of the mucous membrane resulting from the new teeth. Catarrhal conditions of the buccal mucous membranes, such as are observed in stomatitis, also lower the vitality of the epithelial cells, allowing the entrance of tubercle bacilli.

In a few cases the only lesions observed were in the mesenteric glands, which would indicate that the ingested bacilli had safely passed the usual portal of entrance and had been taken up by the lacteals of the intestinal tract and filtered out in the mesenteric lymph glands. Thus Ryder, in charge of the Boston station of the Bureau, has made a careful post-mortem examination of 59,460 hogs, of which number 50 carcasses showed lesions of the mesenteric glands only.

Of far more frequent occurrence are the lesions of the gastro-hepatic glands and of the bronchial glands. In fact, our study of the lesions of hog tuberculosis shows that next in the order of frequency to the submaxillary gland infection comes the combination of the submaxillary with the bronchial glands, then the submaxillary, bronchial, and gastro-hepatic glands, next the submaxillary, bronchial, and gastro-hepatic glands and the liver.

In a certain small number of cases infection probably occurs directly through the respiratory tract, but these instances are extremely rare. Even more infrequent are those cases of tuberculosis which arise as a result of traumatism, especially the infection of castration wounds by the use of infected instruments or otherwise. One boar has come under our observation whose testicles and mucous membrane of the penis were so markedly tuberculous that the genital tract of the sows covered by him could scarcely have escaped infection.

METHODS OF INFECTION.

The most frequent infection of hogs with tuberculosis, as has just been pointed out, occurs, no doubt, through the digestive tract, and in this mode of infection tuberculosis of cattle is very intimately concerned. In those instances in which a marked increase in the number of tuberculous hogs from a certain locality has been noticed and investigated it has too frequently been found that the hogs in question had been fed upon the by-products of a cream separator or that the carcass of some animal succumbing to tuberculosis had been thrown to them for final disposal. The certainty with which either of these two conditions will lead to the infection of the hogs has not heretofore been appreciated in many quarters.

Another source of infection for swine has been shown to exist in the practice of allowing them to run behind a herd of cattle, where the tubercle bacilli excreted with the feces by a tuberculous bovine may readily infect the hogs. Infection of a litter of pigs by a tuberculous sow presents another source of danger. There are a number of other methods of infection which will be mentioned later, but they should be considered of minor importance and must not detract attention from the leading factors in the production of the vast majority of cases of hog tuberculosis, which are unquestionably the milk and feces of tuberculous cattle. When once these are controlled tuberculosis of swine will forthwith be greatly reduced.

The various sources of infection will now be discussed in the following order: (1) The milk of tuberculous cows; (2) the infected feces of cattle and hogs; (3) the feeding of tuberculous carcasses or slaughterhouse offal; (4) the use of diseased brood sows; (5) the sputa of tuberculous attendants, and (6) tuberculous fowls and infected castration wounds.

INFECTION THROUGH THE MILK OF TUBERCULOUS COWS.

Numerous experiments conducted by many scientists in various countries show a great unanimity relative to the ease with which hogs may contract tuberculosis from being fed on milk of tuberculous cows. Thus Gerlach, Zurn, Bollinger, Wesener, Bang, Peuch, Ernst, Pearson, Hills and Rich, and others, have shown that pigs so fed have become tuberculous in as high as 100 per cent of the hogs fed. Furthermore, the experiments of the Bureau of Animal Industry have shown similar results. When hogs were fed on tuberculous milk for only three days the post-mortem examination held one hundred and seven days later showed that 83.3 per cent of the animals had become tuberculous. When hogs received tuberculous milk for thirty days and were allowed to live fifty days longer, 100 per cent of the animals had developed generalized tuberculosis.

That similar experiences occur under natural conditions on the farm has been proved by tracing certain shipments of tuberculous herds to the farm where they were raised and fattened. In one instance a shipment of 74 hogs showed tuberculosis in 61, and investigation brought out the fact that the swine had been fed on the skimmed milk of a creamery in a near-by town. The separator slime from two of the creameries in this town was obtained for experimental purposes, and the inoculation test showed that one of these samples produced tuberculosis in all the guinea pigs inoculated. It is also of interest to know that the hogs slaughtered at the abattoir in this same town for the six months ending June 30, 1907, were tuberculous to the extent of 6.4 per cent, and in March showed the large percentage of 6.69 per cent.

At the present day centrifugal separators for the removal of the cream from the remaining portions of the milk have come into general use in most creameries and upon many dairy farms. During this process the rapid revolutions of the shaft and disks of the machine throw down at the base of the shaft a deposit consisting of dirt, hair, manure, and other impurities which may have found their way into the milk, and mingling with this mass bacteria may also be found in great numbers.

The charge has been repeatedly made that tubercle bacilli are scattered by means of the common practice of distributing the separated milk, or the separator refuse, among the farmers who constitute the patrons of the creamery. Such charges as this should not be made unless some evidence can be presented in substantiation; therefore careful search has been made of samples of the separator sediment from a number of creameries located in widely removed dairy regions to see if they really harbored virulent tubercle bacilli.

When first received at the laboratory this material is examined microscopically. Following this examination all samples, whether

showing the presence of suspicious bacteria in stained preparations or not, are injected into guinea pigs, where the presence of living tubercle bacilli is soon made manifest by the development of tubercular lesions. As a result of such an examination of the products from 15 creameries it has been definitely shown that 5, or 33 $\frac{1}{3}$ per cent, of the samples examined contained virulent tubercle bacilli.

There are no doubt many creameries to which no milk containing tubercle bacilli is delivered and from which the separated milk when divided among the creamery patrons is free from tubercle bacilli, and consequently furnishes a safe and valuable article of food for the calves and pigs to which it is fed. But there are, unfortunately, others, as above indicated, which receive milk daily from one or more cows so affected with tuberculosis that they excrete tubercle bacilli, and these bacilli find their way in large numbers into the cans of separated milk which are returned to the farmers from these creameries. In this way a single cow with a tuberculous udder may spread the disease to numbers of hogs, and may also infect many farms in a large section of country that have never been contaminated before with this destructive disease. This particular means of disseminating tuberculosis could be absolutely prevented by sterilizing the milk, yet this simple precaution is, in the majority of cases, not taken.

In one State where hand separators are quite frequently used on the farm a lot of tuberculous hogs which contained 36 per cent of tuberculous animals was traced to the farm of the raiser, and the State authorities were notified. The latter made a tuberculin test of the cattle producing the milk, with the result that about 22 per cent of them reacted. It will thus be seen that creameries are not alone incriminated, but the skimmed milk from the hand separator, if it comes from a tuberculous herd, is equally dangerous, and the butter-milk produced at the creamery from the infected separated cream is likewise capable of carrying tubercle bacilli and infecting the animals which consume it.

The one great advantage from a hygienic standpoint which the hand separator has over the public creamery is that the milk from an infected herd is usually fed to the one lot of hogs, while the skimmed milk from the creamery is generally all mixed together in a vat and each farmer takes back with him his pro rata of skimmed milk, which is most likely to be produced by several herds of other people's cattle. Hence the skimmed milk of but one tuberculous herd is liable, as a result of this practice, to contaminate the entire product of the vat into which it is placed. For this reason it behooves hog raisers to see that their skimmed milk has been properly heated before they feed it, and the State authorities to make such heating by creameries compulsory as a simple and easy way of greatly reducing hog tuberculosis.

Borgeaud noticed numerous cases of tuberculosis of the bones in young pigs at abattoirs of Lausanne. Instituting inquiries, he was able to connect the outbreak with the feeding of tuberculous milk. At this same period Borgeaud noticed the arrival of an unusual number of cows affected with tuberculosis of the udder from the neighboring farms. A few years previous to this his attention was called to a farm upon which tuberculosis had assumed the character of an enzootic, two, three, or even more pigs dying each day. The owner was unwilling to admit that the fatalities were due to tuberculosis, but felt sure that his swine must have become infected with rotlauf or cholera. It was, however, learned that the pigs on this farm were being fed upon raw milk from a centrifugal separator. When the practice of boiling the separated milk before giving it to the pigs was inaugurated the disease gradually disappeared from among the hogs shipped from this place.

It is also a common practice on farms to feed to hogs all colostral milk not required by the calf. Unless the cow is free from tuberculosis this is a dangerous practice, although no direct connection with this source of infection has been made in our investigation.

INFECTION BY FECES OF CATTLE AND HOGS.

A very prolific source of infection of hogs with tubercle bacilli, and one which closely rivals tuberculous refuse from public creameries, is to be found in the feces of tuberculous cattle. It is a very common practice to allow hogs to accompany cattle about the feed lot, and while doing this they thoroughly work over the feces, thus saving whatever portions of food have passed undigested through the alimentary tract of the bovine. In herds that are healthy this manner of feeding may be commended because of the economy, but wherever there are tuberculous individuals among the cattle the danger of passing the infection on to the hogs by means of the feces becomes very great.

In a series of investigations which were carried on by the Bureau it was found that the feces of tuberculous cattle are often loaded with tubercle bacilli. To test their virulence, tuberculin-tested hogs were placed in isolated pens where a few shovelfuls of such feces were thrown daily while the hogs were fed upon other food which was free from tubercle bacilli. The result was the infection of 25 per cent of the first lot of hogs and 100 per cent of the second lot that were exposed. The tuberculous condition of the cattle was only shown by the tuberculin test, as they were apparently healthy, having no cough or any visible indications of disease.

A somewhat similar experiment was performed by exposing tuberculin-tested hogs solely to the feces of healthy cattle that were

swallowing small quantities of tubercle culture in their drinking water. The exposure lasted eighty-one days, with the result that 75 per cent of the first lot and 100 per cent of the second lot of hogs contracted tuberculosis.

In a recent examination at the Bureau Experiment Station of the manure passed by 12 cows just purchased from dairy farms in the District of Columbia, and affected with tuberculosis to an extent only demonstrable by the tuberculin test, tubercle bacilli were found by Schroeder in over 41 per cent of the cases, both by microscopic examination and by guinea-pig inoculation. The result of this test led to the suggestion that tuberculous hogs might equally well serve as distributors of tubercle bacilli by means of their feces, and an experiment was at once inaugurated in which a litter of healthy pigs was exposed to possible infection by being brought in contact with the feces of hogs that were known to be affected with lesions of tuberculosis. All other possible sources of infection were excluded; and as there was no development of tuberculosis by any of the pigs, it is probable that the feces of tuberculous hogs may safely be considered less dangerous as a conveyer of infection than the same product of tuberculous cattle.

Only recently a probable instance of infection of hogs by cattle feces came under observation. Of 34 hogs which were marketed in one lot 23 were found diseased, and upon investigation it was ascertained that the owner had a herd of dairy cows, the stable manure from which was thrown into the hog yard. The hogs were given no milk, nor were they permitted to mingle with the cattle, but were pastured and fed on corn and what they could gather from the cow manure. In fact, the latter form of exposure was the only plausible explanation of infection, and this was later accepted when the tuberculin test of the herd revealed 19 out of the 27 cows diseased, which test was confirmed when the cattle were slaughtered and found to be tuberculous, some in an advanced stage.

INFECTION THROUGH FEEDING ON TUBERCULOUS CARCASSES OR SLAUGHTER-HOUSE OFFAL.

It is an all too prevalent custom in some sections for hog raisers to buy up all carcasses of animals that have died from various unknown causes and feed them to their hogs. This is a fertile source of infection with parasites and with whatever infectious disease the animal may perchance have died. Several instances of tuberculous hogs being traced to such an exposure have been found. A prominent example occurred in an eastern abattoir where 31 out of 40 hogs were condemned for tuberculosis. When these animals were traced back to the raiser it was found that he was running a large dairy and that

a dairy inspector had by clinical examination condemned one of his cows for advanced tuberculosis. In order to save something, as the owner stated, from the carcass, he hauled it out to the hog pasture and allowed the hogs to consume it, with the above disastrous results. Hogs that had been previously raised by him had never been condemned, and the lot in question were running on a large pasture, separated from cattle, and apparently had no other opportunity to become infected than by the condemned tuberculous dairy cow.

An equally dangerous source of infection is likewise observed in the methods which obtain among some of the small country slaughterhouses. It is not unusual for these houses to get rid of their blood, intestines, viscera, and other inedible parts by feeding them to hogs, a herd of which is usually kept on the premises. This custom is pregnant with danger and is another fertile source for perpetuating the infectious principle of various infectious and parasitic diseases, and particularly a dietetic disease like tuberculosis. The feeding of offal, etc., to hogs on the premises of abattoirs having Government inspection is not permitted by the Federal meat-inspection regulations, and State and municipal regulations should be equally stringent on this feature, as is the case, for example, in the meat regulations of the city of Philadelphia. As the slaughterhouses where hogs are fed in this manner have no Government inspection, we have no records as to the number that become infected. Such hogs are killed by the butcher on the premises where they are fed, and are marketed as healthy meat.

THE USE OF "TANKAGE" AS FEED FOR HOGS.

Another product of the abattoir, tankage, is in an entirely different class from the above, but it nevertheless has been prominently mentioned from several sources as being the cause of much of the tuberculosis in hogs. As to this, however, we have no confirmatory evidence. Such information as we have is presented below, and it will be seen it points in the other direction.

Tankage is made from the trimmings, inedible viscera, and other parts of the carcass which are placed in the tanks and thoroughly cooked under steam pressure so that it comes out as a sterile product. The grease is removed from the surface and the residue is dried at a high temperature, then ground, screened, and placed in 100-pound bags for shipment. Owing to the dryness of the product there is practically no danger of fermentation taking place.

Tankage, meat meal, and other animal food products as feed for live stock, and particularly for swine, have recently attracted a good deal of attention from the farmers, not only because of the prevailing high price of other feedstuffs but also because of recent experiments indicating that greater growth and more fat can be put on the

animals, and at a less cost per pound, than by any other feedstuffs. Tankage has proven a satisfactory substitute for skimmed milk as an adjunct to corn, experiments showing that hogs can be more quickly and cheaply fattened by such a combination than by corn alone. It is generally agreed among feeders that protein is the most important part of the feeding ration as well as the most difficult to procure and the most expensive. Tankage is very high in protein, varying from 10 to 60 per cent, according to the firm manufacturing it, and is commonly called digester tankage.

It having been stated that the increased use of this material as feed for hogs was the cause of the increase in the number of tuberculous hogs condemned at the abattoirs, many inquiries were sent out by the writers to State experiment stations where tankage had been fed to hogs experimentally, for the purpose of tracing, if possible, any cases of tuberculosis due to the consumption of this product. The following extracts from the replies received are of general interest to hog owners, but fail to implicate tankage in any of the blame for the development of tuberculosis in swine.

Prof. E. T. Robbins, assistant animal husbandman at the Iowa State College, Ames, Iowa, writes:

This includes all the evidence we have in regard to the matter of tuberculosis from packing-house by-products, and it seems to me that at least it does not indicate that these by-products are a probable source of infection.

Prof. J. H. Skinner, animal husbandman of Purdue University Agricultural Experiment Station, states:

I may say that we have always carefully examined the hogs that have been fed tankage in our various experiments with this feed, and we have failed, as yet, to discover any tuberculosis in these hogs. We always have some one present when the animals are slaughtered who makes notes on the various organs, and anything of this sort would not be passed by.

From C. S. Plumb, professor of animal husbandry, Ohio State University, we quote:

I have fed tankage to hogs now for some seven or eight years, and during that time have noted only good results. It may interest you to know that three years ago I obtained some tankage which we fed to our pigs here, and they did not do well; we had swine plague affect the herd, and lost a number of young pigs. Suspicion was attached to the tankage, and we discontinued feeding it. The next year, however, the remainder of the tankage, of which there was considerable, was all fed and no injurious effects noted.

Prof. R. S. Shaw, of the Michigan Agricultural College, writes as follows:

We have been using tankage at this institution as a swine food quite extensively for about three years, both in experimental work and ordinary feeding. The great bulk of our hogs are sold alive. Some of them are dressed and placed on the market by Lansing butchers. Some of them are shipped to Detroit and Buffalo by dealers. In these three years we have dressed approximately

about 200 head of hogs in our own little slaughterhouse. No indications of the presence of this disease have been discovered thus far.

The opinions above given are confirmed by certain feeding experiments conducted by the Bureau with tankage mixed with cotton-seed meal in various proportions and fed to 71 hogs for about six months. No indication of tuberculosis was found, after careful post-mortem examinations, in any of the hogs receiving tankage.

INFECTION FROM DISEASED BROOD SOWS.

A case of this character was thoroughly investigated by Clancy, of the Bureau of Animal Industry, and is full of instructive features. It had been noticed that a certain shipper of hogs to the East St. Louis market occasionally sent in a load containing many tuberculous animals, and close inquiry and consultation of shipping records showed that these loads were mainly composed of hogs from one particular farm. An inspector was consequently detailed to visit this place and to discover, if possible, the source of such wholesale infection. In his report to Washington he wrote:

But four cows are milked, and no part of their milk is fed to pigs. The brood sows are kept in several widely separated lots on different parts of the farm, and they are moved about frequently.

A physical examination, it would seem, is of minor importance when we consider the evidence which points conclusively to the fact that several of the brood sows must surely be tuberculous.

It was found that 28 tuberculous hogs were shipped from this farm in May, 1902. In July, 1904, 11 affected hogs left the farm, and in September of the same year 14 others followed, and were condemned by Federal inspectors at the abattoirs. In 1905 there were 27 tuberculous swine shipped from this farm, making a total of 80 animals which had contracted tuberculosis on this farm within a period of four years. It was further shown that a year or two previous to the first appearance of tuberculosis among the hogs in question the owner had purchased some imported cattle from a neighbor who was engaged in importing cattle from England. Some of the cattle from the importer's farm were slaughtered about this time and were found to be so badly infected with tuberculosis that the carcasses were totally destroyed. Tuberculosis was conveyed from the importer's farm to the farm under investigation, and after a time made itself manifest among the cattle on the place, with the result that one of them died. Her carcass was hauled out to the feed lot and turned over to the hogs. After this date constant trouble had been experienced through the development of tuberculosis by the hogs at this place.

We must infer that the brood sows on this farm became affected through eating the tuberculous carcass of the cow, and that, retaining

the disease, they continued to infect their offspring for several seasons following. The sows were retained from year to year while their litters were fattened and sent to market, and it was in these young animals that tuberculosis was found to have developed to such remarkable proportions.

McFadyean reports that a litter of young sucking pigs was referred to him for investigation because they were unthrifty, dull, and purging. The remaining swine of the farm consisted of a boar, three sows, and another litter of young pigs, all of which appeared to be perfectly healthy. The pigs were about 7 weeks old at the time of the examination, and in spite of this early age all of them were found to be affected with generalized tuberculosis. No report of the sow which produced these pigs could be obtained other than the statement that she appeared to be quite healthy with no evidences of mammary tuberculosis. McFadyean considers it more than probable that a post-mortem examination of this brood sow would have revealed either tuberculosis of the generative organs or of the mammary glands. The first pig examined led McFadyean to decide that infection must have occurred previous to birth, while the lesions of the other two indicated a later infection by way of the digestive canal.

In an experiment conducted by the Bureau a sow was artificially infected by inserting a long hypodermic needle under the subcutaneous tissues of the mammae parallel with the skin, and in withdrawing a few drops of tubercle culture were allowed to flow gradually from the point of the needle. The litter of pigs born to this animal all became tuberculous, although the sow on post-mortem showed only six small subcutaneous abscesses the size of hazelnuts. Another experiment was made with a tuberculous sow having a litter of eight pigs; four of the latter were placed in a pen by themselves into which were thrown the feces of the mother. The negative result of this feature of the experiment has already been referred to (p. 225). The remaining four were allowed to suckle the tuberculous sow, and two of them contracted the disease, thus establishing most positively the danger of perpetuating the disease through the use of diseased breeding animals.

INFECTION BY TUBERCULOUS ATTENDANTS.

Attendants and caretakers who feed and care for hogs should be free from tuberculosis, since hogs are susceptible to human tuberculosis. Bang records the appearance of tuberculosis among hogs on a farm where this disease had never been seen before, which resulted from tuberculous attendants who were in the habit of spitting in the hogs' feed and about the premises.

Dinwiddie, as a result of comparative tests of human and bovine tubercle bacilli, reached the conclusion that pigs "are susceptible to infection with both bovine and human tubercle," and to judge from these tests "bovine tubercle is no more active for these animals than human sputum. The kind of pathological changes induced in the two cases are identical. The liability to generalization of the disease in pigs, a feature which has been noticed by other observers, is noticeable also in these inoculation experiments." In a later review of these tests Dinwiddie states that "pigs were found to be readily infected and prone to suffer from generalized disease by inoculation and feeding with both varieties of tubercle or tubercle bacilli in cultures."

The British Royal Commission on Tuberculosis has also shown that hogs are susceptible to human tuberculosis. This commission considers the power of resistance of hogs to the human tubercle bacillus to be considerably less than that possessed by cattle.

Knese reports the infection and loss of an entire litter of 3-months-old pigs consisting of 11 animals. These pigs had been bred upon the premises from healthy stock, and all possible sources of infection could be eliminated save that of sputum from a tuberculous daughter of the family, who was very sick with tuberculosis of the lungs during the entire summer, and who died from the ravages of this disease in the fall. During the progress of the disease the young woman coughed badly, raising large amounts of expectoration which was collected in a dish at the bedside. This dish was emptied into the yard each morning, then washed out and the wash water likewise thrown into the yard. The small pigs had liberty to run about the yard each day, and undoubtedly became infected through contact with the human tuberculous sputum which was so freely placed within their reach.

In a recent conversation with Ryder, in charge of the Boston station of the Bureau, he informed us that out of a lot of 76 hogs that had been fed upon swill gathered from some of the hotels of Boston 37 were found to be tuberculous at the time of slaughter. It can not, of course, be stated positively that any of these animals were infected through material gained from tuberculous people at these hotels, but because of the possibility of such contamination the case is mentioned. It should be stated that the cattle on this farm were healthy, having been frequently tested in the last three or four years, and there was no other apparent source of infection than the hotel swill.

INFECTION FROM TUBERCULOUS FOWLS AND THROUGH CASTRATION WOUNDS.

The frequent association of pigs and fowls has suggested the possibility in European countries that in some cases tuberculosis of hogs

may result from exposure to chickens affected with tuberculosis. As avian tuberculosis is extremely rare in this country, little importance may be attached to this method of infection, although the finding of avian tubercle bacilli in hog tissues by Weber and Bofinger indicates that hogs are susceptible to this form of the disease.

The danger of infection of the scrotum at the time of castrating hogs through the contaminated knife of the operator or otherwise has been reported by Meyer. This method of becoming diseased is likewise of such rare occurrence that to mention it is sufficient for our purpose.

SYMPTOMS OF TUBERCULOSIS IN HOGS.

Few hogs ever show by outward symptoms that they are affected with tuberculosis. In fact, the hogs that disclose tuberculosis at the time of slaughter are frequently the finest appearing animals in the drove when they are brought to the abattoir. Should indications of tuberculosis be present they will usually consist of a general appearance of unthriftiness, which might result from other diseases and therefore does not afford any very definite indication that tuberculosis is present.

Where the disease has progressed to an advanced stage of generalization various symptoms may appear. Abdominal tuberculosis is frequently accompanied by general disturbance of the digestive functions, and constipation or diarrhea may be shown. Advanced pulmonary tuberculosis will be shown by a persistent dry, harsh cough, and by acceleration in breathing, especially on exercise. This cough is similar to that caused by lungworms and can not be differentiated from it.

Interference with both respiratory and digestive functions may be seen when the disease is widely generalized, and the systemic alterations will be shown by progressive emaciation and weakness. Localization of the disease in bones or joints may produce lameness and other visible indications, but these are comparatively very rare.

In the majority of cases no intimation of the presence of the disease will be given until the animal is slaughtered, and the discovery of a number of tuberculous hogs in a drove of apparently prime, well-finished animals is often the cause of great surprise and disappointment to their owner, and in such cases the lesions may be sufficient to prove the disease generalized and the tubercle bacilli to be so widely distributed as to render the meat unfit for food purposes.

Forty-four hogs that had been fed upon the milk of a tuberculous cow for a period of two months at the Oklahoma Agricultural Experiment Station were subjected to official inspection at the abattoir, and 21, or 47.72 per cent, of them were condemned as tuberculous. The effect of tuberculosis on the physical condition of these hogs

was not very marked, as may be seen from the following statement of Doctor Lewis:

Some of the animals that showed a generalized condition of the disease at the time of the post-mortem examination had had the disease almost a year, yet they were in apparently good physical condition. In one that died from the effects of the disease the physical condition was not such as to cause suspicion of generalized tuberculosis. In fact the entire lot of diseased hogs were in a marketable condition so far as flesh was concerned, and a number of them were killed under official inspection, their condition being such that they were considered fit for market.

Among a lot of hogs in which tuberculosis is known to exist it is occasionally possible to select a tuberculous individual by palpation of the throat, when enlarged cervical lymphatic glands may be detected, which will afford a reasonable ground for a suspicion of tuberculosis. In such a drove a sow with swollen mammæ would likewise suggest the presence of a tuberculous mammitis, but these cases are extremely infrequent.

In those cases where the disease is not characterized by prominent symptoms, but where the animals are suspected of having the disease, the tuberculin test is recommended. This makes it possible to slaughter the reacting animals in the early stages of the disease and thus obtain some remuneration for the carcasses and at the same time get rid of the infection. This is especially important in holding over brood sows, as our experiments have indicated that the milk of these sows may contain tubercle bacilli and thus infect the young pigs.

THE TUBERCULIN TEST.

In reviewing the questions of detection and eradication of tuberculosis in hogs it is noticeable at once that there are but few recorded instances in which reliable tuberculin tests have been made. This may be due to the fact that the temperature of a hog is subject to rapid changes under conditions which would not cause noticeable variations with cattle. These alterations of temperature in individual hogs are so great within short spaces of time, and from apparently insignificant causes, that it seems at first thought that no change caused by the injection of tuberculin could ever be sufficient to permit one to reach any definite conclusion as to the presence or absence of tuberculosis.

In the experiments of Schroeder and Möhler, of the Bureau of Animal Industry, recorded in Bulletin 88, it was found desirable to keep the hogs as quiet as possible during the test, it having been shown that excitement affects the temperatures of hogs very quickly. Each hog was therefore placed in a rectangular crate about twelve hours before the first temperature was taken, and remained in this confinement continuously until the tuberculin test was completed. The

crates, while large enough to permit the hogs to get up and down easily, were still close enough to prevent their turning around or moving backward and forward to such an extent as to interfere with the insertion of the thermometers. Crates that are made 4 feet long, 1 foot 2 inches wide, and 2 feet high, inside measurement, have proven entirely satisfactory in restraining hogs weighing from 50 to 150 pounds. Unless use is made of crates, or of some other satisfactory means of restraint, it is difficult, if not impossible, to obtain trustworthy temperatures of hogs.

The dose of tuberculin used was estimated on a basis of $\frac{1}{2}$ c. c. for each hundredweight, or fraction thereof, of the weight of the animals tested. For instance, a pig weighing 75 to 100 pounds would receive $\frac{1}{2}$ c. c. of tuberculin, while one weighing 150 to 200 pounds would receive 1 c. c. The injections were made directly under the skin at the inner surface of the thigh, and in no instance were any harmful results noted following the puncture.

For a practical tuberculin test it has been found sufficient to have the temperature of the hogs taken every two hours from 8 a. m. to 6 p. m., inclusive, on the day of injection, and at the same hours on the day following, with the tuberculin injection made at 10 p. m. on the first day. The temperature before injection should be taken as frequently as after injection, and at corresponding hours, because of the very erratic character of the temperature of hogs and because of the slight circumstances that may inadvertently be the cause of marked variations. It should especially be borne in mind that the value of the results obtained depends entirely upon keeping the hogs absolutely quiet during the whole of the test, and this point may be more readily gained if the animals are kept in their crates for twelve hours at least before the first temperature is taken.

In reaching a decision as to the presence of tuberculosis in a hog, as shown by the temperature readings, it is somewhat unsafe to base a condemnation upon the comparison of the maximum reading before injection with the maximum of the day following, but by averaging the temperatures for each of the two days during which they have been taken one is enabled to reach very satisfactory conclusions by comparing these averages. It is essential that the temperatures should be taken at corresponding hours on each day of the test, if results are to be determined by means of averages. By this method it was found in a test experiment with 68 hogs that only two failures (less than 3 per cent) occurred. In these tests no hog was condemned as tuberculous until it had shown a persistent average elevation of temperature of 1° F. throughout the second day. In the two failures mentioned one tuberculous hog failed to react, and another animal gave a reaction, but at post-mortem examination no tubercular lesions could be found.

A report has been received from Doctor Luckey, State veterinarian of Missouri, which shows that hogs may be tested satisfactorily and to good advantage with tuberculin if handled quietly and kept so closely confined that no chasing or driving will be necessary at the time of taking temperatures.

As a proof that carefully bred pedigreed swine are not necessarily more susceptible to tuberculosis than the more common varieties, mention is made in the *Veterinary Journal* of the testing with tuberculin of a number of purebred animals intended for export to Finland. The temperature of each pig, which was numbered for identification, was carefully taken, the average for the boars being 39° C., and for the sows 39.16° C., the higher temperatures of the sows being thought to be due to excitement, owing to their racing about when let out of their pen. The temperatures of all of the pigs were higher at the preliminary reading than at subsequent testings, probably the result of being caught and handled.

The tuberculin was injected at 10 p. m., and the temperature of each pig was taken at 7 o'clock the following morning and each two hours afterwards until the veterinarian of the purchasing party was convinced that no trace of tuberculosis existed in any of the animals. The variations in the temperatures of the various pigs were comparatively slight, that of one boar being from 39.2° to 38.5° C., and of one sow from 39.4° to 38.5° C., the highest being in each case the one taken first. The average temperature of all the pigs at the various testings was 38.6425° C., or nearly 0.3° C. less than those first taken.

LESIONS.

The vitality of hogs or their powers of resistance to disease are necessarily lowered by the unnatural conditions which frequently obtain in hog raising, namely, the forced feeding for fattening and the small feeding pens in vogue in certain districts. When the enormous growth of a hog is considered, when it is realized that in the short space of eight or ten months its development is frequently 250 to 300 pounds—a proportionate increase of weight unknown to any other species of domestic animals—the great metabolic changes which must necessarily occur can be appreciated. Such rapid development is very likely to take place at the expense of the disease-resisting powers of the animal.

When tuberculosis results the lesions usually observed are discrete and of a chronic type, at times retrogressive and at other times slowly progressive, as manifested by calcareous deposits and fibrous encapsulation. It is not infrequent, however, that a more extensive and spreading disease is seen, and the lesions indicate a severe infection and rapid generalization of the bacilli, which in these animals may quickly follow the initial attack. And whether the disease assumes

an acute, subacute, or chronic type, tuberculous growths may soon be found attacking lymph glands in widely separated parts of the body. Indeed, a most extensive development of the disease has been reported by McFadyean in pigs from 8 to 10 weeks old, born of healthy parents and evidently infected by tuberculous skim milk. In these cases the lesions had not only undergone extensive caseous degeneration, but had even become partially calcified. Furthermore, he reported the observance of pigs 6 to 8 weeks old with generalized lesions which had become more or less calcified.

As soon as the tubercle bacillus invades the tissue changes develop, resulting in the formation of nodules or tubercles which may be either translucent or of a yellowish-white color. At first these tubercles are isolated and discrete, but later they may coalesce and form large areas of tuberculous tissue. Microscopically, the tubercle is formed of the same elements as are noted in the tubercles of other animals, namely, epithelioid, lymphoid, and giant cells. The earliest development of the tubercle consists of the invading bacilli surrounded by round cells. In a short time these cells are circumscribed by a layer of epithelioid and giant cells, which in turn are surrounded by a zone of lymphoid cells. As the tubercle grows the cells in the center of the tubercle die, become fragmented, and form a necrotic mass which enlarges as the tubercle increases in size. Sometimes these tubercles become indurated with fibrous tissue, or may go on to calcareous infiltration, or the necrotic areas may be surrounded by fibrous tissue elements, all of which cause the glands to be enlarged, hard, and knotty. These cases of calcareous infiltration in the hogs of this country are much more frequent than the Old World literature would lead one to believe occurs in European hogs.

One peculiar condition which is at times observed in tuberculous glands and which may prove perplexing to some inspectors is the arbor-vitæ or dendritic appearance which these lymph nodes may assume as a result of hyaline degeneration. This rather unusual form of a tuberculous gland probably arises from the lymph bringing to the node the tubercle bacilli, which, acting as an irritant, lead to the change, and which, being arrested in the nodes involved, permit the other tissues to escape unless further exposure follows. The delicate capsule and connective-tissue trabeculæ of these glands at first become excessively hypertrophied at the expense of the lymphoid elements. The tissue then partly or entirely undergoes a process of hyaline degeneration, making a tortuous, almost dendritic, course of this form of degeneration not unlike the branching of the arbor-vitæ of the cerebellum. Many of the lymphoid cells, particularly those in the vicinity of the connective-tissue septæ, suffer a similar fate. No necrotic areas have been observed, but isolated and clustered tubercle bacilli

may be seen in the earlier stages in the hyaline areas, which evidently retards the multiplication of the micro-organisms and brings about a partial process of healing, as in the more advanced stages tubercle bacilli can not be discovered either by the microscope or animal inoculations.

As a general rule, the lymph glands become enlarged, and caseation usually starts at several points where the tubercles had started, causing numerous small yellowish foci often surrounded by a reddened, inflamed zone. These areas are composed of degenerated gland substance, and are sometimes intermingled with pus; at other times they are of a cheesy consistency, and more frequently gritty through the deposit of calcareous particles.

The lesions, therefore, consist first of miliary granulations, which become caseous and which may rapidly become calcareous. Even in the absence of tubercle bacilli, the microscopic picture of stained sections shows the typical tubercular follicles almost always rich in giant cells. Furthermore, the insertion of a small piece of the susceptible tissue under the skin of a guinea pig will usually result in the production of the disease in three or four weeks, when the animal may be chloroformed and a diagnosis made.

As the disease is essentially produced by ingestion, the glands and tissues associated with the digestive tract are the most frequent seats of infection. Indeed, the superior cervical glands (in almost all cases the submaxillary gland) are nearly always affected, as at the post-mortem examinations held by Bureau inspectors over a consecutive period on 120,000 tuberculous hog carcasses, 93.3 per cent were found to contain lesions in these glands. The large tonsils and the large number of lymph sinuses in the lymph glands probably account for this great frequency. Next in importance are the bronchial glands, of which 27.2 per cent were diseased, while the gastro-hepatic chain of glands was involved in 21.6 per cent of the cases. In all these cases the lesions may involve the entire lymph structure, or only the central or several irregular points, and may be either caseous, calcareous, or caseo-calcareous. The mesenteric lymph glands showed lesions in 18.1 per cent of the carcasses examined. The liver was affected in 9.2 per cent of the cases, and showed either yellowish miliary foci, which were caseous and scattered, not only on the surface but also in the parenchyma, or the larger, irregular nodules, varying from a hemp seed to a shellbark in size. They are at times quite fibrous in consistency and may contain a caseous center, or calcification may occur as the disease advances and the alterations become more considerable. The lungs are the next tissue to be most frequently affected, as is represented by 7 per cent of the carcasses above recorded. The morbid anatomy of the lungs in this disease simulates



TUBERCULOUS LUNGS OF HOG.



A. ROSEN & CO. BALTIMORE

TUBERCULOUS AND NORMAL SPLEENS OF HOGS.

that observed in human tuberculosis more than in cattle tuberculosis. In fact, the disease bears many points of similarity to infantile tuberculosis in the human. There may be tuberculosis pneumonia involving large areas of the lungs, causing collapse of the marginal portion. There may be irregular-sized grayish or yellowish areas of caseation, as is so often seen in cattle; but not infrequently there are observed large numbers of miliary gray or translucent foci, showing evidence of generalization as a result of the bacilli being disseminated by the blood stream. (See Pl. II.)

The picture presented by tuberculosis of the spleen, which showed lesions in 3.8 per cent of the above carcasses, is very peculiar to one who is familiar only with cattle tuberculosis. The spleen is usually darker in color and the surface is quite rough and nodular, depending upon the number and size of the tubercles. Unlike the spleen of a tuberculous cow, these nodules occur not often on the serous membrane, but in the parenchyma. They vary from the size of a half pea to as large as a shellbark. The external pale or light-red nodules are raised above the surface of the organ and frequently show fibrous tissue bands radiating from the centrally necrotic area. (See Pl. III.)

The lesions observed in the mediastinal glands are similar to those in other glands and were noted in 1.8 per cent of the cases, while the sublumbar glands were found affected in 0.9 per cent of the carcasses. The serous membranes may show an eruption of tuberculous granulations, and these have been noted on the pleura in 0.1 per cent and on the peritoneum in 0.006 per cent of the cases. The generative organs are rarely affected. The bones, however, are more frequently attacked, those of the vertebral column, pelvis, and of the articulated extremities showing tubercular affection in 0.007 per cent of the carcasses. Tuberculosis of the muscles has been noted, but not so frequently as of the bones and joints. The lesions are usually rather limited to one region. Their aspect varies. They may be rounded, isolated nodes of the diameter of a pea or bean, composed of a fibrous capsule, with caseous contents. In other cases the muscles are sown with whitish-gray confluent tubercles, with centers that are usually calcified early in the development of the disease. The extreme rarity of lesions in the kidney is shown by the finding of but 3 cases in the 120,000 tuberculous carcasses. As examinations of the prepectoral, prescapular, and inguinal glands were not made in all instances, no percentages are given for them.

Occasionally also ulcers and tuberculous nodules are noticed on the mucosa or submucosa of the small intestines, especially of young pigs, but these likewise are rare, and when found usually accompany generalized lesions elsewhere in the body.

COMPARISON OF THE TUBERCULOUS LESIONS OF HOGS AND CATTLE.

While the lesions in hogs may be considered in their principal features like those in cattle, there are some points of difference which may be readily noted. As the disease in the former animals is essentially a food tuberculosis, the primary seat of infection is almost universally along the alimentary canal. The submaxillary glands are more frequently affected than any other tissue in hogs, while in cattle these are quite infrequently diseased. In fact, the submaxillary glands of hogs bear a somewhat similar position to the retropharyngeal glands of cattle, although the former are more frequently affected in hogs than the latter are in bovines. The lungs are less frequently diseased and generally secondarily involved, not primarily as in cattle. Furthermore, the pleura and the peritoneum are even less commonly affected than the lungs. The liver and the spleen, especially the latter, are more often diseased in hogs. The mammary glands of hogs are less frequently affected than in cattle, while the bones, joints, and muscles are more liable to disease in hogs. The lymph glands, even those remotely situated, are more frequently affected than in cattle (with the exception of the mediastinal gland, which is only occasionally diseased in hogs), and there is a very large percentage of this disease in hogs which only shows involvement of one, two, three, or even more groups of lymph glands without regular secondary infection.

Ulcers in the intestines, while infrequent in both species, are probably more commonly observed among swine. The formation of grape-like clusters on the parietal serous membranes is quite infrequent, and when it is seen it usually results from contact with an adjacent tuberculous organ. The lesions undergo calcification much earlier in hogs, and this form of degeneration occurs as often as, if not oftener than, in cattle, and frequently takes place when the lesions are quite small. The tubercle bacilli are quite elusive on microscopic examination, but are more readily seen in our experience with hog lesions than with bovine. Finally, unlike the disease in cattle, tuberculosis of hogs is most frequently seen at the abattoirs in animals under 1 year of age, due, of course, to the fact that the majority of hogs are marketed at this age.

RELATION OF HOG TUBERCULOSIS TO MEAT INSPECTION.

The post-mortem inspection of hogs by the Bureau officials is very thorough, and is so arranged that tuberculous carcasses are quickly separated from those that are healthy. The various phases through which the hog passes after his arrival at the stock yards, where he is yarded, sold, weighed, driven to the packing house, killed, scalded, and run through the scraper, do not particularly concern us until we

meet him at the point where, lying on the traveling table, his head is almost severed from the body. Here he is examined by a veterinary inspector of the Bureau, who palpates and, if necessary, incises the submaxillary glands which have been exposed by the cut just made by the butcher for removing the head. Should these glands prove to be healthy, the hog is allowed to pass down to the rail unmolested; if on the other hand these glands are seen to be tuberculous the animal is marked and is then run into a separate compartment called the retaining room, without being eviscerated. Most of the tuberculous animals are detected here at the header's bench, our records, as previously mentioned, showing that 93.3 per cent of the tuberculous hogs support lesions in the glands in the region of the throat.

From the header's bench the hogs which have not been tagged are sent along the rail to the gutter's bench, where another veterinary inspector is stationed, whose duties consist in examining each hog, giving special attention to the viscera. His search is not limited to the detection of tuberculosis, but he must watch for any of the diseases proscribed by the regulations of the Bureau. As there is a certain percentage of hogs that show tuberculosis in the visceral organs without giving any evidence of the same in the cervical glands, the inspector at the gutter's bench is able to detect a number of tuberculous subjects in addition to those already tagged by the veterinarian at the header's table. In this case the inspector is guided by the appearance of the lesions in the liver, spleen, lungs, or visceral glands.

Another inspector has recently been installed at the point on the line where the carcasses are split, it having been found that occasionally vertebral lesions and lesions of the serous membranes will exist, even when the visceral organs are apparently normal.

Returning to the hogs which were tagged by the inspector on the heading bench, these are passed along to the retaining room, where they are eviscerated by a separate lot of butchers, using separate tools, under the supervision of a fourth veterinary inspector. By this method the affected parts or tissues are prevented from coming in contact with the healthy meats and are passed directly from the retaining room to either the "condemned" room or to the offal tanks. In the retaining room by this time there will be many hogs on the rail that are only slightly affected with tuberculosis, and these are now beheaded, split, trimmed, and passed on to the cooling rooms.

It is not a very difficult problem to pass judgment on the carcass of a hog affected with tuberculosis when the lesions are slight on the one hand, or when they are widespread on the other. Most sanitarians are agreed to pass the former class for food, after removing the diseased parts, and to condemn the latter class. In the great majority of hogs retained by our inspectors the lesions are local, even

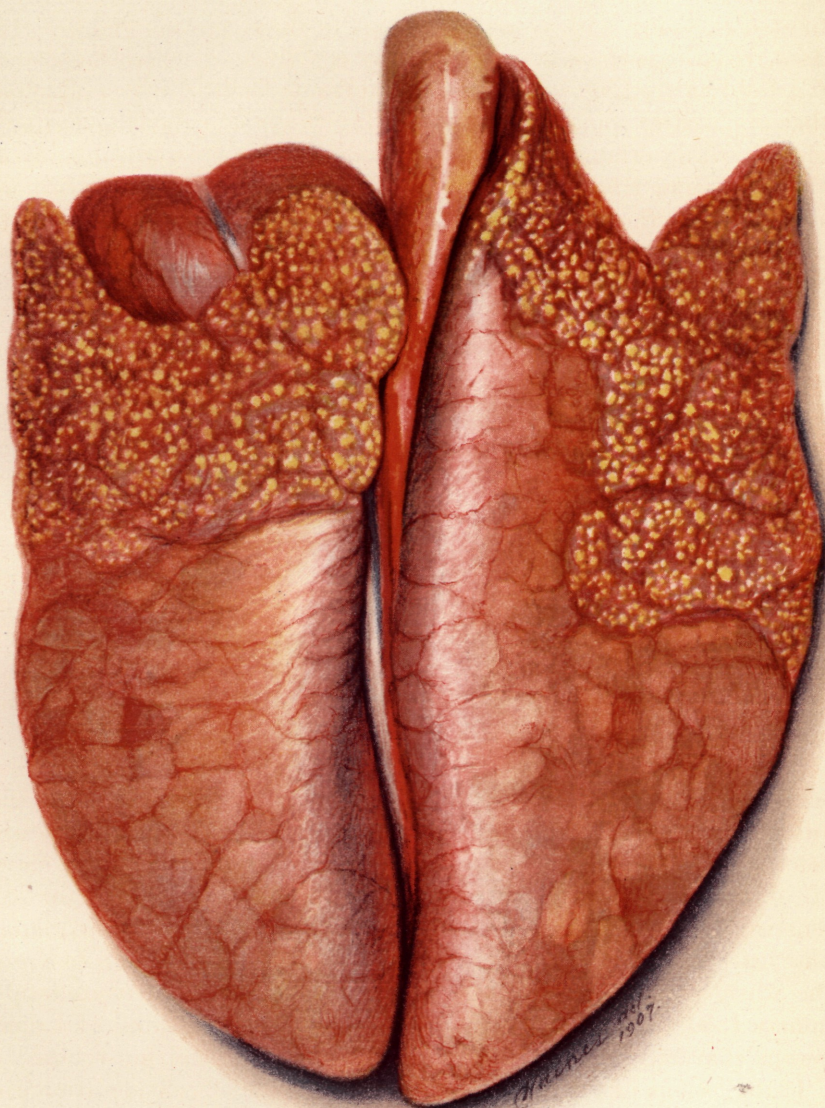
though one or more groups of organs are affected. It is not unusual to see hogs with lesions in the submaxillary, bronchial, and hepatic lymph glands, or any combination of them, in which the foci are of the same character, size, and consistence, and apparently of the same age, and in these cases the animals are judged to be infected by a limited exposure with resulting lesions in these various glands. Indeed, from experiments performed by the Bureau, where hogs were fed for two feedings on cultures of tubercle bacilli, it was observed that apparently some of the tubercle bacilli entered the submaxillary glands, while others lodged in the bronchial and hepatic glands at about the same time. These are purely primary lymphatic invasions, and these are the cases in which it is customary for the inspector to remove all diseased parts from the carcass and allow the remainder to be passed as suitable for food.

The principle governing such disposal of this class of carcasses is that, there being no evidence that the tubercle bacilli have been taken up from the portal of entry to the body by the blood vessels, there could have been no scattering of such organisms through the muscular parts of the carcass, and these may therefore be eaten with impunity. It is in cases of this class that danger from the development of toxins has been suggested. This, however, has been disproved by the experiments of Eber and ourselves.

The disposal of cases of generalized tuberculosis is likewise an easy matter, for it is evident that the infectious organisms have gained entrance to the blood vessels, and by this means have been conveyed to all parts of the carcass, infecting the meat more or less completely. The rendering of such carcasses in the offal tank is the only rational disposal that can be made of them.

There are, however, other cases in which the development of disease has reached a stage which may admit some discussion as to the advisability of using the meat for food. Many tuberculous hogs are found that give no evidence of cachexia or wasting, and that show on examination that the disease has not become generalized or extensive, although it has advanced beyond the point of primary glandular infection. Here the inspector must act carefully, trying to avoid the waste or loss of any meats that may be safely converted into human food, and at the same time being sure that nothing of a dangerous character is allowed to enter the cooling or cutting rooms.

If the lesions of tuberculosis in the animal under consideration are so located that they may be readily removed, a third method of disposing of the carcass may be selected. The carcass may be carefully trimmed, the tuberculous parts being consigned to the offal tank, while the trimmed meat, comprising the bulk of the edible portions of the animal, is placed in the lard-rendering tank, where it must be



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LUNG OF HOG WITH VERMINOUS PNEUMONIA.



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FAT NECROSIS INVOLVING (1) THE OMENTUM AND (2) THE PANCREAS OF HOG.

cooked by steam at a temperature not lower than 220° F. for not less than four hours for the extraction of the lard which it contains. This temperature, of course, is sufficient to destroy any bacilli that may possibly be present in the meat.

DIFFERENTIAL DIAGNOSIS.

There are but few diseases which are liable to be mistaken for tuberculosis in the hog, but under certain conditions verminous pneumonia, caseous lesions following an attack of swine plague, fat necrosis, pyemia, echinococcus cysts in the liver, or degenerations of the lymph glands caused by invasions of the young forms of the parasite known as *Lingulatulula tænioides*, may cause lesions bearing considerable resemblance to those of tuberculosis.

In the lesions following swine plague it will be found that there is no involvement of the thoracic lymph glands, which practically always become affected with tuberculosis in all tubercular infections of the lungs. Mistakes between this disease and tuberculosis should not be made, as the lungs in cases of swine plague will not show the grayish areas simulating tubercles until the disease has run a protracted course, allowing the areas of the lungs to become caseated. Examination of the skin of the hog and the internal viscera will likely give evidences which will greatly aid in a differential diagnosis.

Cysts of the *Echinococcus multilocularis* in the liver may at times be confusing, but they are usually whiter in color than tubercular lesions of the same size, and when cut open the central contents of the cyst may be readily removed, which condition is totally unlike that to be found in tubercular nodules. In this affection the adjoining lymph glands are not changed as they are in cases of tuberculosis.

Invasion of the lungs of swine with strongyles or roundworms may produce lesions very similar at first glance to those of tuberculosis (see Pl. IV), but the adjacent lymph glands are not involved. Careful examination of the air tubes by opening them will readily disclose the worms to the naked eye, and thus establish the verminous origin of the lesions. It is said that the pseudo-tubercles which occur with this condition are in reality due to the encystment of the female worm or of the ova and embryos in the air sacs and cells. The long-necked tapeworm, *Cysticercus tenuicollis*, may invade the lungs and cause similar pneumonia, but this only rarely occurs. The finding of worms in the various visceral organs of the hog should serve to direct the attention to the air passages in cases of difficult diagnosis, as it is very common to find a verminous invasion of the lungs accompanying an invasion of the stomach or intestines.

Relative to the mistaking of lesions caused by the invasion of *lingulatulula* larvæ into the lymph glands of hogs for lesions of tuberculosis, Edelmänn gives the following:

The recognition of the larval site is not difficult if the affected areas and glands are cut open. They may be mistaken for tubercular areas if it is not recalled that—

1. Tubercular areas do not preferably occur in the peripheral zones of the lymph glands, but are usually found in their cortical portions.

2. Tubercular areas caseate from the center outward, and are surrounded by a gray peripheral layer, while *lingulatulula* foci possess a uniform caseous consistency.

3. Caseous tubercular areas are yellow, while caseated *lingulatulula* areas are greenish in color.

4. In beginning calcification tuberculous areas retain their yellow color; the pentastomum areas on the contrary turn gray; and

5. In *lingulatulula* areas the larvæ or their hooks are demonstrable.

In pyemia the liver and lungs are the principal seats of the metastatic abscesses, which are soft and frequently encapsulated, but, unlike in tuberculosis, the corresponding lymph glands do not become caseated. Furthermore, there may be evidences of a general blood infection, as cloudy swellings of the organs, hemorrhages in the kidneys, lymph glands, and serous membranes, or a suppurative wound on the surface of the body through which the pyogenic micro-organisms entered.

Fat necrosis is generally considered to be the result of the fat-splitting ferment of the pancreas acting upon living adipose tissue. The fat is split up into fatty acid and glycerin by this ferment; the glycerin is absorbed and the fatty acid which is left combines with the salts to form a soap. The lesions occur in the form of dead-white, slightly raised, opaque, and grumous areas of variable size, and usually of a more or less circular outline. (See Pl. V, fig. 1.) They are of firmer consistence than the adjacent fat. In the majority of cases the lesions are confined to the immediate vicinity of the pancreas, and are found in the fat between the lobules and immediately surrounding the gland. (See Pl. V, fig. 2.) It is quite common, however, to find them considerably removed, and appearing in any part of the peritoneum, on the kidney fat, and even as far back as the pelvic cavity. The fat of the abdominal wall is frequently affected, and may contain many small areas from the size of a pinhead to that of a half dollar, or it may be so severely involved that very little normal fat will be found lining the abdominal wall. These patches may also occasionally appear under the parietal pleura and the parietal serous membrane of the pericardium. The lesions of fat necrosis are usually secondary to some alteration of the pancreas, while in tuberculosis the pancreas is very rarely involved, and then only in

conjunction with lesions in other viscera. Furthermore, the caseation so characteristic of tuberculosis is absent in fat necrosis.

PREVENTIVE MEASURES.

REMOVAL OF AFFECTED ANIMALS.

The first step to be taken in preventing the further spread of tuberculosis is to remove all affected animals, whether hogs or cattle, from the premises, as these will only serve as sources of infection so long as they are allowed to mingle with healthy animals. In dealing with affected herds of cattle it has been found best in most cases to apply the tuberculin test to the entire herd as a means of selecting the tuberculous animals, but with a drove of hogs in which tuberculosis has appeared there can be no doubt that the best and surest method of procedure will in nearly every case be found in the slaughter of the entire drove as soon as they can be put in a marketable condition. They should be slaughtered at an abattoir under Federal inspection, so that proper disposal may be made of affected carcasses.

This means of removing from the farm all of the centers of infection which exist among its swine is made possible and practicable by the ease with which a new drove may be built up from fresh foundation stock. With cattle the offspring seldom number more than one to a cow in a year, and the young cow does not produce until 2 years of age. With swine reproduction may be expected when the young sow is 1 year old, and instead of producing but one at a birth from six to ten may reasonably be expected. If properly handled, the first litter of young may be weaned in time to allow the sow to farrow again the same year. This shows how very rapidly a farm may be stocked with healthy swine after the total slaughter of a tuberculous lot. The early age at which the sow may be bred, her capacity for breeding twice a year, and the plural number of her offspring are forceful arguments for the total destruction of every diseased drove of hogs and the breeding up in clean, healthy quarters of a sound, healthy drove in its stead.

As tuberculosis seldom attacks the swine of a farm except through tuberculous cattle, the tuberculin test should be applied to all of the cattle on the place, and all tuberculous animals among them should be destroyed at the time of disposing of the hogs.

DISINFECTION.

With the hogs all removed from the place and no tuberculous cattle remaining, attention should next be given to disinfecting the premises, so that no center of infection may be left to contaminate future purchases of live stock. The disinfection of pens and stables may be accomplished by thoroughly cleaning them, scrubbing the floors with

hot water, brushing down all loose dust from the walls, and tearing out all woodwork which has become partly decayed. The interior of the pens or stables should then be carefully covered with a coating of lime wash containing 1 part of formalin to 30 parts of the lime wash, or 4 ounces of formalin to each gallon of the lime preparation. The yards should be carefully cleaned at the same time, especial attention being given to the removal of all rubbish and litter from the dark, shady corners. Lime, or a 3 per cent solution of carbolic acid, may then be sprinkled upon these dark portions of the yards. In all of the open portions of the yard the action of the direct rays of the sun will very quickly destroy all the virulence of the scattered tubercle bacilli.

The premises now being cleansed, healthy foundation stock may be procured, and if proper attention is given to keeping the cattle of the farm free from tuberculosis and to supplying the hogs with suitable food, the owner may feel every reasonable assurance that he has seen the last of tuberculosis among his swine. The trouble, time, and expense required will be more than repaid by the advantages gained.

It has been quite conclusively shown that swine acquire their infective tuberculous material from cattle, mankind, or poultry, but principally cattle.

Tuberculosis can not develop spontaneously in swine, but must be acquired from some outside source, and the farmer whose yards and stables have been thoroughly freed from the disease need fear no reappearance of the disease, except when introduced from some outside point of infection. In case the disease has only recently been introduced among the hogs it would be advisable to apply the tuberculin test that the affection may be detected in the early stages, in order that the hog raiser may clean up his herd with as little loss as possible.

PASTEURIZATION OF ALL MILK PRODUCTS USED FOR FEED.

The heating of all milk when received at public creameries to 176° F., or 80° C., has been found most effective in preventing the spread of tuberculosis to the animals consuming the by-products of such creameries. Denmark was one of the pioneers in this movement, having in 1898 passed a law requiring all skimmed milk and all buttermilk to be warmed to 185° F. before it could be distributed from any creamery to its patrons for feeding purposes. It was found, however, that this degree of heat was harmful to the product, and in 1904 the required temperature was reduced to 176° F., experiments having proved that no tubercle bacilli could withstand this amount of heat. In practically all of the Danish creameries from this latter date the whole milk has been heated to the required point,

thus assuring butter that is free from tubercular organisms, as well as by-products that are safe for use in feeding hogs or calves. The result of these regulations has been most satisfactory. The spread of tuberculosis to farms previously free, through the skimmed milk or the buttermilk from creameries, has been very markedly checked, and suppression of the disease in hogs has been plainly noticeable.

Treating of creamery milk as a cause of the spread of tuberculosis among hogs, Moussou makes the statement that sterilization of the by-products of creameries and cheese factories results in the disappearance of tuberculosis of an alimentary origin among the hogs fed with them, and the hog owners do not longer fear losses from this disease.

Borgeaud has cited an instance in which a serious outbreak of tuberculosis among hogs was overcome by boiling all of the separated milk before feeding it to the subsequent litters of young pigs.

PROPAGANDA AMONG FARMERS AND DAIRYMEN.

While pamphlets, popular articles, and public notices would be extremely useful in eradicating tuberculosis in swine, it would probably be more satisfactory to explain to the hog raiser by word of mouth the methods to be followed. As this suppression of tuberculosis is entirely voluntary on his part, a powerful propaganda is of the greatest value, and the veterinarian is the best equipped man available for the work. The State should also assist by employing veterinarians to give public lectures in towns and townships, as is being done at present in Sweden. We now have absolute knowledge that the vast majority of cases of hog tuberculosis are produced by—

1. Raw milk and slime from creameries.
2. Hand-separated milk from tuberculous cattle.
3. Feeding behind tuberculous cattle.
4. Feeding tuberculous carcasses.
5. Feeding slaughterhouse offal.

It therefore behooves veterinarians to educate their clients as to the proper methods of preventing this disease, as they would recommend a proper feeding ration or proper construction of a stable. Hog raisers should be instructed to (1) scald all raw products returned from the creamery; (2) to test their cattle if a hand separator is used on the farm, or in the absence of such a test, to scald the skimmed milk; (3) to let the hogs feed behind cattle only when the latter have withstood the tuberculin test; (4) to feed carcasses of animals that have died from any cause, or offal from the slaughterhouse, only after the meat and offal have been thoroughly cooked.

Sooner or later the packer and slaughterer are going to buy hogs subject to the post-mortem inspection, as they are at present doing in some of the large packing centers with certain classes of female

cattle; and the hog raiser who continues to fatten his hogs with tuberculous material should be made to sustain the losses arising from his lack of knowledge, skepticism, or indifference. The innocent purchaser, who can not be familiar with the methods of feeding in vogue on the farms of the different breeders, should not be expected to bear such losses, nor should the intelligent hog raiser who produces healthy hogs by carrying out minutely the known and proved methods of prevention be obliged to bear a portion of the burden caused by the careless or ignorant hog raiser, as is the case at present. To-day the hog buyer must make his purchases with the absolute knowledge that a certain proportion of his purchase will be condemned for tuberculosis, and as the post-mortem examination is the only key to the extent of the disease, the careful breeder must suffer equally with the careless one. This is not equitable. When the packer buys subject to the post-mortem results the intelligent hog raiser will get more for his healthy hogs than he does now, and the ignorant breeder will get less for his tuberculous hogs, which is as it should be.

It would be money well expended if butchers and packers who are losing so much from hog tuberculosis would employ veterinarians in their vicinity to write popular articles giving correct views on how to suppress tuberculosis on the farm and mail them to their hog shippers and hog raisers in furtherance of this plan of eradication. Extermination of hog tuberculosis is practicable, relatively easy, and should be attained without delay before the disease has gained too much headway.

One of the favorable steps in this direction, and one that will undoubtedly tend to check the advance of tuberculosis, is the enforcement of laws similar to the following, which have been enacted by the States of Iowa and Minnesota:

Laws of the thirty-first general assembly of Iowa (1906).

Be it enacted by the general assembly of the State of Iowa:

SECTION 1. That every owner, manager, or operator of a creamery shall before delivering to any person any skimmed milk cause the same to be pasteurized at a temperature of at least one hundred and eighty-five (185) degrees Fahrenheit.

SEC. 2. Whoever violates the provisions of this act shall, upon conviction, be liable to a fine of not less than twenty-five (\$25) dollars nor more than one hundred (\$100) dollars.

General laws of Minnesota for 1903, to prohibit and prevent the manufacture or sale of unhealthful or adulterated dairy products.

Be it enacted by the legislature of the State of Minnesota:

SECTION 10. That all creameries before delivering to any patron any skimmed or separated milk shall have pasteurized the same at a temperature of at least 180° F.

Similar laws to the above are at present being considered for Wisconsin and Illinois, but have not as yet been enacted.